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FORM PTO-1390 (REV. 12-2001) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY 'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		L-392
		U.S. APPLICATION NO. (If known, see 37 CFR 1.5 10/031957
INTERNATIONAL APPLICATION NO. PCT/EP 00/06957	INTERNATIONAL FILING DATE July 20, 2000	PRIORITY DATE CLAIMED July 21, 1999
TITLE OF INVENTION METHOD FOR PRODUCING A TORSION SPRING		
APPLICANT(S) FOR DO/EO/US MAIK WIEMER et al.		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [x] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [x] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [x] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [x] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [x] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [x] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [x] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [x] A substitute specification. (included in First Prelim. Amend.)
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [x] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information: (see page 3 for continuation)

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21. [x] The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [x] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	3 - 20 =	0	x **$18.00**	$	
Independent claims	1 - 3 =	0	x **$84.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$	

TOTAL OF ABOVE CALCULATIONS =	$ 1020	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	
SUBTOTAL =	$	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	
TOTAL NATIONAL FEE =	$ 1020	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$ 40	
TOTAL FEES ENCLOSED =	$ 1060	
	Amount to be refunded:	$
	charged:	$

a. [x] A check in the amount of $ 1060 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ____________ in the amount of $ __________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [ ] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. __________. A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

SIGNATURE

Elliott N. Kramsky

NAME

27,812

REGISTRATION NUMBER

U.S. APPLICATION NO. (if known)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
	PCT/EP 00/06957	L-392

16. Other items or information:

International Application (ANTRAG);

International Publication WO 01/07869 A1 including International Search Report;

Notice Informing the Applicant of the Communication of the International Application to the Designated Offices;

Written Opinion (SCHRIFTLICHER BESCHEID) Under Rule 66 dated March 16, 2001 in German and English languages;

Response to Written Opinion of March 16, 2001 dated May 30, 2001 in German and English languages;

International Preliminary Examination Report (MITTEILUNG UBER DIE UBERSENDUNG DES INTERNATIONALEN VORLAUFIGEN PRUFUNGSBERICHTS) dated October 19, 2001; and

Copy of German Letters Patent (URKUNDE) of German patent application 199 34 174.5 with DE 199 34 174 C1 attached.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	:	
MAIK WIEMER et al.	:	Examiner:
Serial No.	:	
Filed:	:	
For: METHOD FOR PRODUCING A	:	Art Unit
TORSION SPRING	:	

FIRST PRELIMINARY AMENDMENT (SUBSTITUTE SPECIFICATION)

Box Non-Fee Amendment
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Please amend the patent application transmitted herewith by entry of the attached patent application as a substitute specification in place of the English language translation of International patent application Serial No. PCT/EP 00/05186 and enter the following changes to the claims as they appear in the substitute specification as filed.

IN THE CLAIMS

Cancel Claims 1 through 3 without prejudice.

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Add new Claims 4 through 6 as follow:

4. A method for producing a torsion spring with low torsional compared to transverse stiffness in the lateral and vertical directions as part of a micromechanical torsion spring/mass system, from two wafers or wafer composites, comprising the steps of:

a) producing a spring extending over the entire thickness of said wafer or wafer composite, said spring having a V-shaped cross section that is laterally delimited by [111] planes on at least one side edge region of each wafer or wafer composite, by anisotropic wet-chemical etching; then

b) rotating said two wafers or wafer composites through 180°; and then

c) joining said two wafers or wafer composites to one another oriented in a mirror-image fashion with respect to one another so that an overall X-shaped torsion spring cross-section is formed in the region of the two V-shaped spring cross sections.

5. A method as defined in Claim 4, further including the step of forming an insulating layer on the surface that faces the other wafer or wafer composite during joint process on at least one wafer or wafer composite.

6. A method as defined in Claim 5, characterized in that said two wafers or wafer composites are joined to one another by silicon direct bonding.

REMARKS

Transmitted herewith is a Substitute Specification for amending the enclosed patent application, the U.S. national phase of International application Serial No. PCT/EP 00/06957 which was filed in the EPO Receiving Office on July 20, 2000.

The International application was filed in the German language and enclosed with this filing is a literal translation of that International application as filed.

The enclosed Substitute Specification is submitted for the purpose of facilitating examination by correcting and clarifying the literal English translation so as to be more readily understood by a U.S. patent examiner. To further facilitate examination, the literal translation has been rearranged into a format consistent with U.S. practice. The extensive nature of the editorial revisions made herein would render it impractical and confusing to indicate changes upon the English language translation of the International application.

The enclosed Substitute Specification adds no new matter to International application PCT/EP 00/06957.

A copy of the substitute specification is enclosed with

changes to the English language translation of the International patent application indicated thereon by underlining (additions to language of the translation) and brackets (deletions from language of the translation).

Claims 1 through 3 of the substitute specification are identical to those of the English language translation of the International application. Applicant has amended the substitute specification by cancelling Claims 1 through 3 without prejudice and adding new Claims 4 through 6. New Claim 4 includes all limitations of former Claim 1 while new Claim 5 includes all limitations of former Claim 2 and new Claim 6 includes all limitations of former Claim 3. In each case, the new claim only restates the corresponding English language translation of the former claim in better form for U.S. examination.

Respectfully submitted,

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Attorney for Applicants

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SUBSTITUTE SPECIFICATION

Title: METHOD FOR PRODUCING A TORSION SPRING

Inventors: Maik Wiemer
Karla Hiller
Detlef Billep
Uwe Breng
Bruno Ryrko
Eberhard Handrich

BACKGROUND

Field of the Invention

The present invention relates to methods for producing a torsion spring for a micromechanical torsion spring/mass system. More particularly, the invention pertains to the production of a torsion spring from two wafers or wafer composites that possesses low torsional relative to transverse stiffness in the lateral and vertical directions.

Description of the Prior Art

Silicon torsion springs are known in various design variants in microstructuring. For example, C. Kaufman, J. Markert, T. Werner, T. Gessner and W. Dötzel in "Characterization of Material and Structure Defects on Micromechanical Scanners by Means of Frequency Analysis" Proceedings of Micro Materials (1995) p. 443, describe relatively long narrow strips, for example, for the

articulated mounting of torsion mirrors. The spring cross section is of trapezoidal shape. Springs are formed on opposite wafer edges and produced by etching pits from the back surface during structuring of the springs from the front surface. J. Choi, K. Minami and M. Esahi in "Silicon Angular Rate Sensor by Deep Reactive Ion Etching," Proceedings of the International Symposium on Microsystems, Intelligent Materials and Robots (Sendai, Japan, 1995), pages 29 through 32, propose the production of a rectangular torsion cross section, in particular for suspending a tuning fork resonator, with a relatively high aspect ratio (height:width ratio ≥ 4) by deep RIE (reactive ion etching). The two torsion spring cross sections have the disadvantage of sensitivity to transverse stresses. The spring cross-section produced by the first method is particularly sensitive to vertical bending, while the spring cross section produced by the second method is particularly sensitive to lateral bending.

German patent document DE 28 18 106 A1 discloses a torsion spring of cross-shaped cross-section that has low torsional compared to transverse rigidity in the lateral and vertical directions. A tube for a sensor that also acts as a torsion spring is disclosed by P. Enoksson

et al. in "A Silicon Resonant Structure for Coriolis Mass-Flow Measurements," Journal of Microelectromechanical Systems, Vol. 6, No. 2 (June 1997) at pages 119 through 125. The tube is produced using the Coriolis principle, by turning wafers, placing them against one another in a mirror-symmetrical manner and bonding them, in each case with a trench formed therein.

In a further application of such torsion springs, rotary mirrors and micromechanical rotation rate sensors are mentioned in International patent publication WO 96/38710. In particular, Figure 8 of that document illustrates a double-layer vibratory structure that is held in a frame by a cross-shaped spring joint formed from the wafer layers. This cross-shaped spring joint, which is formed from a total of four individual spring elements, improves stiffness in the wafer levels, a fact referred to in the patent publication. For a vibratory structure of this type, in which the vibrators, arranged in plate form above one another, form a micromechanical rotation rate sensor based on the Coriolis principle, it is desirable to optimize the cross-shaped spring joint in such a way that transverse stiffness relative to torsional stiffness is as high as possible in the direction of the wafer planes and perpendicular thereto (i.e. in the lateral and vertical

directions).

SUMMARY AND OBJECTS OF THE INVENTION

It is therefore the object of the invention to provide a method for producing an optimized torsion spring for a micromechanical torsion spring/mass system.

The invention addresses the above object by providing a method for producing a torsion spring with low torsional compared to transverse stiffness in the lateral and vertical directions, as part of a micromechanical torsion spring/mass system from two wafers or wafer composites. Such method is begun by producing a spring extending over the entire thickness of the wafer or wafer composite by anisotropic wet chemical etching. The spring has a V-shaped cross section that is laterally delimited by [111] planes on at least one side edge region of each wafer or wafer composite.

The method then continues by rotating the two wafers or wafer composites through 180°. Finally, the two wafers or wafer composites are joined to one another, for example by bonding, while oriented with respect to one another in a mirror-image fashion so that an overall x-shaped torsion of the two V-shaped spring cross sections.

The foregoing and other features of the invention will become further apparent from the detailed description that follows. Such description is accompanied by a set of drawing figures. Numerals of the drawing figures, corresponding to those of the written description, point to the features of the invention with like numerals referring to like features throughout both the written description and the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a first method in accordance with the invention for producing a torsion spring with an X-shaped cross-section; and

Figure 2 illustrates a second method in accordance with the invention for producing a torsion spring with an X-shaped cross-section.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 illustrates a first method in accordance with the invention for producing a torsion spring with an X-shaped cross section from two wafers. In Figure 1, the starting point for the method is two identical wafers, while in Figure 2, which illustrates a second method in accordance with the invention, the

starting point for the method is two wafer layer composites, separated or electrically insulated from one another along their common surface plane by an insulating layer 1. Strip-shaped etching masks 2 are applied in the lateral edge region of the wafers or the wafer composites. A spring 3 with a V-shaped cross section, which is laterally delimited by [111] planes, is then produced in the edge region of each wafer or wafer composite by anisotropic, wet-chemical etching. Two of the wafers or wafer composites which have been prepared with a V-shaped spring in this way are rotated through 180° with respect to one another and are then joined to one another oriented mirror image symmetrically with respect to one another. The joint process may be employed so that the desired transversely rigid torsion spring of X-shaped cross section is formed as a suspension element for a uniform torsion spring/mass system structure.

If the invention is used in combination with the production of micromechanical rotation rate sensors, the basis used (to be able to release different excitation potentials or reset signals, on the one hand, and feed and readout potentials, on the other hand, to the outside) is preferably a two-layered wafer composite for each of the plate-type oscillators. To be able to supply or remove

four different electrical potentials by the crossed springs, it is advantageous for an insulating oxide to be formed on the surface of at least one of the wafers or the wafer composite that faces the other wafer or the other wafer composite during bonding.

The X-shaped, integrally joined torsion spring cross section formed by the method increases the ratio of transverse stiffness to torsional stiffness as opposed to a rectangular cross section and also as compared to individual crossed spring elements, as described in WO 96/38710, by more than two orders of magnitude.

A particular advantage of the method of the invention resides in its simple technology. The torsion spring is not affected by time-dependent etching processes. Only one etching step takes place that is critical in terms of time duration in the overall assembly of the two V-shaped springs.

The dimensional accuracy of the torsion spring, the masks of which obviously include long, narrow structures, is dependent, inter alia, upon precise matching of the crystal direction [110] to mask orientation. To insure precise orientation of the wafers

with respect to one another and/or of wafers with respect to masks, the setting reference for the joint process, in particular silicon direct bonding, and the lithography is oriented in the [110] crystal direction using suitable chemical, plasma-chemical and/or mechanical means. This orientation may, for example, be affected by initially providing the wafers with an etching mask which is produced parallel to the ground bevel of a mask edge. The wafers are then anisotropically overetched using this mask, resulting in the formation of a new reference bevel, which then serves as an optical or mechanical (preferably gravity-assisted adjustment) reference for the joint process and the lithography, i.e. the mask orientation.

While this invention has been described with reference to its presently-preferred embodiment, it is not limited thereto. Rather, the invention is limited only insofar as it is described by the following set of patent claims and includes within its scope all equivalents thereof.

What is claimed is:

1. A method for producing a torsion spring as part of a micromechanical torsion spring/mass systems, which can be obtained from two wafers or two wafer composites, and has a low torsional stiffness compared to the transverse stiffness in the lateral and vertical directions, characterized in that

- a spring (3) which extends over the entire wafer or wafer composited thickness and has a V-shaped cross section which is laterally delimited by [111] surfaces, is produced on at least one side edge region of each wafer or safer composite by anisotropic wet-chemical etching, and
- the two wafers or wafer composites whcih have been prestructured in this way are rotated through 180° and are bonded to one another oriented in a mirror-symmetrical fashion with respect to one another, so that overall an X-shaped torsion spring cross section is formed in the region of the two V-shaped spring cross sections.

2. The method as claimed in claim 1, characterized in that, on at least one wafer or wafer composite, an insulating layer (4) is formed on the surface which faces the other wafer or wafer composite during bonding.

3. The method as claimed in claim 2, characterized in that the two wafers or wafer composites are joined to one another by silicon direct bonding.

ABSTRACT

A method for producing a silicon torsion spring capable, for example, of reading the rotation rate in a microstructured torsion spring/mass system. The system that is produced achieves a low torsional stiffness compared to a relatively high transverse stiffness in the lateral and vertical directions. The method proceeds from a wafer or wafer composite and, upon suitable mask coverage, a spring with a V-shaped cross section is formed by anisotropic wet-chemical etching which preferably extends over the entire wafer thickness and is laterally delimited only by [111] planes. Two of the wafers or wafer composites prepared in this way are rotated through 180° and joined to one another oriented mirror-symmetrically with respect to one another, so that overall the desired X-shaped cross section is formed.

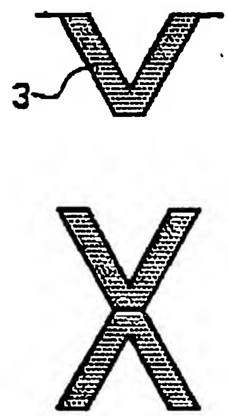

FIG. 1

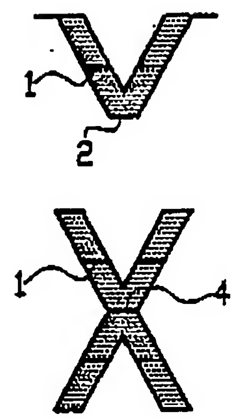

FIG. 2

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Method for producing a torsion spring

The invention relates to a method for producing a torsion spring as part of a micromechanical torsion spring/mass system which can be produced from two wafers or two wafer composites and have a low torsional stiffness compared to the transverse stiffness in the lateral and vertical directions.

DE 28 18 106 A1 has, for example, disclosed a torsion spring which, on account of a cross-shaped cross section, has a low torsional rigidity compared to the transverse rigidity in the lateral and vertical directions.

Journal of Microelectromechanical Systems (Vol. 6, No. 2, June 1997, pp. 119-125) discloses a tube of a sensor which also acts as a torsion spring. This tube is produced using the Coriolis principle, by turning wafers, placing them against one another in a mirror-symmetrical manner and bonding them, in each case with a trench formed therein.

As a further example of an application of such torsion springs, rotary mirrors and micromechanical rotation rate sensors are pointed out, as described in International patent application WO 96/38710. In particular, Figure 8 of this document shows a double-layer vibratory structure which is held in a frame by means of a cross-shaped spring joint formed from the wafer layers. This cross-shaped spring joint, which is formed from a total of four individual spring elements, improves the desired stiffness in the wafer levels, to which fact reference is made in the abovementioned WO document.

For a vibratory structure of this type, the vibrators of which, which are arranged in plate form above one another, form a micromechanical rotation rate sensor

based on the Coriolis principle, however, it is desirable to optimize the said cross-shaped spring joint, specifically in such a way that, compared to the torsional stiffness, a transverse stiffness which is as high as possible in the direction of the wafer planes and perpendicular thereto, i.e. in the lateral and vertical directions, results.

The invention is therefore based on the object of describing a method for producing an optimized torsion spring for a micromechanical torsion spring/mass system.

Silicon torsion springs in microstructuring are already known in various design variants. For example, the specialist article in literature reference [1] describes relatively long narrow strips, for example for the articulated mounting of torsion mirrors. The spring cross section is trapezoid-shaped. The springs are formed on opposite wafer edges and are produced by etching pits from the back surface during structuring of the springs from the front surface. Literature reference [2] describes the production of a rectangular torsion cross section, in particular for suspending a tuning fork resonator, with a relatively high aspect ratio (height:width ≥ 4), deep RIE (Reactive Ion Etching) being proposed as the production method. These two torsion spring cross sections have the drawback of also being sensitive to transverse stresses. The spring cross section produced using the first method is particularly sensitive to vertical bending, while the spring cross section produced using the second method is particularly sensitive to lateral bending.

In a method for producing a torsion spring as part of a micromechanical torsion spring/mass system, which can be obtained from two wafers or two wafer composites, and has a low torsional stiffness compared to the transverse stiffness in the lateral and vertical

directions, the invention is characterized in that a spring which extends over the entire wafer or wafer composite thickness and has a V-shaped cross section which is laterally delimited by [111] surfaces, is produced on at least one side edge region of each wafer or wafer composite by anisotropic wet-chemical etching, and in that the two wafers or wafer composites which have been prestructured in this way are rotated through 180° and are bonded to one another oriented in a mirror-symmetrical fashion with respect to one another, so that overall an X-shaped torsion spring cross section is formed in the region of the two V-shaped spring cross sections.

If the invention is used in combination with the production of the abovementioned micromechanical rotation rate sensors, the basis used - in order to be able to release different excitation potentials or reset signals, on the one hand, and feed and readout potentials, on the other hand, to the outside - is a preferably two-layered wafer composite for in each case one of the plate-type oscillators. In order, for example, to be able to supply or remove four different electrical potentials by the crossed springs of the torsion springs produced using the method according to the invention, it is advantageous, on at least one of the wafers or the wafer composite, for an insulating oxide to be formed on that surface which faces the other wafer or the other wafer composite during bonding.

The X-shaped, integrally joined torsion spring cross section which is formed as a result of the method increases the ratio of transverse stiffness to torsional stiffness compared to a rectangular cross section, but also compared to individual crossed spring elements, as are shown in the abovementioned WO document, by more than two orders of magnitude.

A particular advantage of the method according to the invention resides in the simple technology, since the torsion spring is not influenced by the time-dependent etching processes, so that overall, in the combination of the two V-shaped springs, only one etching step which is critical in terms of time takes place.

The dimensional accuracy of the torsion spring, the masks of which obviously include long, narrow structures, is dependent, inter alia, on precise matching between the crystal direction (110) and the respective mask orientation. To ensure that this is achieved, in the invention, for precise orientation of the wafers with respect to one another and/or of wafers with respect to masks, the setting reference for the bonding, in particular silicon direct bonding, and the lithography is oriented in the (110) crystal direction using suitable chemical, plasma-chemical and/or mechanical means. This orientation may, for example, be effected by initially providing the wafers with an etching mask which is produced parallel to the ground bevel of a mask edge. Then, the wafers are anisotropically overetched using this mask, with the result that a new reference bevel is formed, which then serves as an optical or mechanical, preferably gravity-assisted adjustment reference for the silicon direct bonding and the lithography, i.e. the mask orientation.

The invention is explained in more detail below with reference to two exemplary embodiments, in which:

Fig. 1 shows a first method variant according to the invention for producing a torsion spring with an X-shaped cross section from two wafers, and

Fig. 2 shows a second, modified procedure.

In the case of Figure 1, the starting point for the production method is two identical wafers, while in the

case of Figure 2 the starting point for the production method is two wafer layer composites, which are separated from one another or electrically insulated from one another along their common surface plane by an insulating oxide layer 1 having a layer thickness of, for example, up to 4 μm. Strip-shaped etching masks 2 are applied in the lateral edge region of the wafers or of the wafer composite. Then, a spring 3 with a V-shaped cross section, which is laterally delimited by [111] surfaces, is produced in the edge region of each wafer or wafer composite by anisotropic, wet-chemical etching. Then, two of the wafers or wafer composites which have been prestructured with a V-shaped spring in this way are rotated through 180° with respect to one another and are bonded to one another oriented mirror-symmetrically with respect to one another, in particular by silicon direct bonding, so that the desired transversely rigid torsion spring which is X-shaped in cross section is formed, as a suspension element for a uniform torsion spring/mass system structure.

List of literature from the prior art

Lit.[1] C. Kaufmann, J. Markert, T. Werner, T. Geßner, W. Dötzel: Charakterisierung von Material- und Strukturdefekten an mikromechanischen Scannern mittels Frequenzanalyse [Characterization of material and structure defects on micromechanical scanners by means of frequency analysis], Proceedings of Micro Materials '95, p. 443

Lit.[2] J. Choi, K. Minami, M. Esahi: Silicon Angular Rate Sensor by Deep Reactive Ion Etching, Proc. of the Int. Symposium on Microsystems, Intelligent Materials and Robots, 1995, Sendai, Japan, pp. 29-32

Patent Claims

1. A method for producing a torsion spring as part of a micromechanical torsion spring/mass system, which can be obtained from two wafers or two wafer composites, and has a low torsional stiffness compared to the transverse stiffness in the lateral and vertical directions, characterized in that
   - a spring (3) which extends over the entire wafer or wafer composite thickness and has a V-shaped cross section which is laterally delimited by [111] surfaces, is produced on at least one side edge region of each wafer or wafer composite by anisotropic wet-chemical etching, and
   - the two wafers or wafer composites which have been prestructured in this way are rotated through 180° and are bonded to one another oriented in a mirror-symmetrical fashion with respect to one another, so that overall an X-shaped torsion spring cross section is formed in the region of the two V-shaped spring cross sections.

2. The method as claimed in claim 1, characterized in that, on at least one wafer or wafer composite, an insulating oxide (4) is formed on the surface which faces the other wafer or wafer composite during bonding.

3. The method as claimed in claim 2, characterized in that the two wafers or wafer composites are joined to one another by silicon direct bonding.

Abstract

Method for producing a torsion spring

To produce a silicon torsion spring, by means of which, for example, the rotation rate in a microstructured torsion spring/mass system can be read, the aim being to achieve a low torsional stiffness compared to a relatively high transverse stiffness in the lateral and vertical directions, the invention proceeds from a wafer or wafer composite and, after suitable mask coverage, a spring with a V-shaped cross section, which preferably extends over the entire wafer thickness and is laterally delimited only by [111] surfaces, is produced by anisotropic wet-chemical etching. Two of the wafers or wafer composites which have been prestructured in this way are rotated through 180° and are bonded to one another oriented mirror-symmetrically with respect to one another, so that overall the desired X-shaped cross section is formed.

A particular advantage of the invention is that the production technology for the laterally and vertically rigid twist spring is relatively simple.

(Fig. 1)

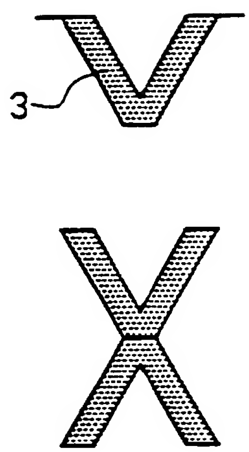

FIG. 1

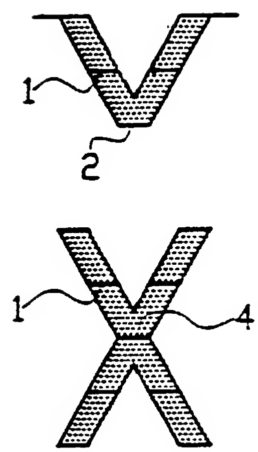

FIG. 2

L-392 (LTF-169-PCT/US)

DECLARATION

As the below named inventors, we hereby declare that:

Our residences, post office addresses and citizenships are as stated below next to our names.

We believe we are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD FOR PRODUCING A TORSION SPRING (pursuant to the United States national stage of International patent application PCT/EP00/06957 filed July 20, 2000), the specification and claims of which are attached hereto.

We hereby state that we have reviewed and understand the contents of the above identified specification, including the claims.

We acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, 1.56(a).

We hereby claim foreign priority benefits under Title 35, United States Code, 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Federal Republic of Germany
Patent Application 199 34 174.5
Filed: July 21, 1999

We hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, we acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, 1.56(a) which occurred between the filing of the prior application and the national or PCT international filing date of this application: NONE

Rec'd PCT/PTO 05 JUN 2002
10/031957

ATTORNEY DOCKET NO. L-392 (LTF-169-PCT/US)

POWER OF ATTORNEY

I, WOLF SCHWÄBE, an officer of LITEF GmbH, a corporation organized under the laws of the Federal Republic of Germany and assignee of the entire right, title and interest in the patent application entitled METHOD FOR PRODUCING A TORSION SPRING of joint inventors MAIK WIEMER, KARLA HILLER, DETLEF BILLEP, UWE BRENG, BRUNO RYRKO and EBERHARD HANDRICH, hereby appoint KEITH M. WILSON, Registration No. 40,230; SCOT R. HEWITT, Registration No. 35,191; and ELLIOTT N. KRAMSKY, Registration No. 27,812 as attorney(s) and/or agent(s) of said corporation, with full power of revocation in myself to conduct all business in the United States Patent and Trademark Office in connection therewith. 3

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LITEF GmbH

By: ______

Title: Director of Engineering

We hereby declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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